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15/ENG01/012

CHEMICAL ENGINEERING

CHE 574 ASSIGNMENTS

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1 ASSIGNMENT ONE

QUESTION ONE

The first law of thermodynamics states that energy can neither be created nor destroyed in an isolated system but can be converted from one form to another. The different forms of energy that exist are; electrical energy, mechanical energy, thermal energy, radiant energy, gravitational energy, sound energy.

a- Electrical energy is expressed in terms of power as shown in Equations (1-1) and (1-2) below

$$\text{Energy} = \text{power} * \text{time} \quad \textbf{(1-1)}$$

Power=V*I power $=I^2$ *R

$$\text{Energy} = \text{V} * \text{I} * \text{T} \ ; \ \text{Energy} = I^2 * \text{R} * \text{T} \quad \textbf{(1-2)}$$

Where;

I= current (amps)

V=voltage (volts)

R=resistance (ohms)

b- Thermal energy is part of the internal energy of a thermodynamic system. Its expressed as

$$\text{Q} = \text{m} * C_p * (T_f - T_i) \quad \textbf{(1-3)}$$

Where;

q=heat transferred (energy)

M=mass

C_p= specific heat capacity

T_F and T_i = final and initial temperatures respectively

c- Radiant energy can be expressed as

$$\mathrm{F} = \sigma * T^4 \tag{1-4}$$

$$F = \frac{P}{A}$$

Where;

F=energy flux

P=net radiated power

A=radiating area

σ =Stefan-Boltzmann constant

T= temperature in kelvin

d- Gravitational energy is expressed as :

$$\mathrm{U} = \frac{\mathrm{GMm}}{r} \tag{1-5}$$

Where;

U=gravitational potential energy

G=universal gravitational constant

M=mass of the earth

M=mass of the body

r=distance of the body from the centre of the earth e- Mechanical energy: this is expressed as the summation of the energy experienced by a moving body and energy experienced by a body at rest

Potential energy: Energy held by an object at rest

$$\mathrm{P.E} = \mathrm{m} * \mathrm{g} * \mathrm{h} \tag{1-6}$$

Where

m = mass in kilogram (kg)

g = acceleration due to gravity (approx. 9.8 m/s^2)

h = height (m)

Kinetic energy: Energy exalted by an object in motion

$$\mathrm{K.E} = \frac{1}{2}mv^2 \tag{1-7}$$

m= mass of object (kg)

v=velocity of the moving object (m/s)

Mechanical energy =P.E +K.E

$$\text{mechanical energy } = \mathrm{mgh} + \frac{1}{2}mv^2 \tag{1-8}$$

f- Sound energy: sound energy is the form of energy that can be heard by man.

$$\mathrm{I} = \frac{\mathrm{P}}{A} \tag{1-9}$$

Where

I=sound intensity (W/m^2)

P=power (W)

A=Area (m^2)

Area is given as a distance of $4\pi r^2$ (surface area of a sphere)

QUESTION TWO

Sustainable energy refers to the use of energy in a way that meets the needs of the present and will still be available for the future generations to use. Sustainable energy is often used interchangeably with the term renewable energy. Sustainable energy contributes to reducing the dependence on the use of fossil fuel resources, thus providing the opportunity to reduce greenhouse gases. Some of the resources which are considered as sustainable energy are solar, wind and hydro electrical energy.

Non-sustainable energy refers to the energy which cannot be readily replaced by natural means at a quick pace to keep up with its consumption. Resources which are considered as non-sustainable energy are earth minerals and metal ores, fossil fuels, (coal, petroleum, natural gas) and ground water in certain aquifers. This non-sustainable energy are said to be not eco-friendly because when they are turned, they create pollution and carbon dioxide.

QUESTION THREE

The most sustainable energy sources include all renewable energy sources such as hydro electrical, biomass, geothermal, wind, and wave, tidal and solar energies. The sustainable energy sources can be used to generate electricity, to heat and cool buildings and to power transportation systems and machines. The major resources for a sustainable energy mix include;

-Wind energy

-solar energy

-hydro energy

-Biomass energy

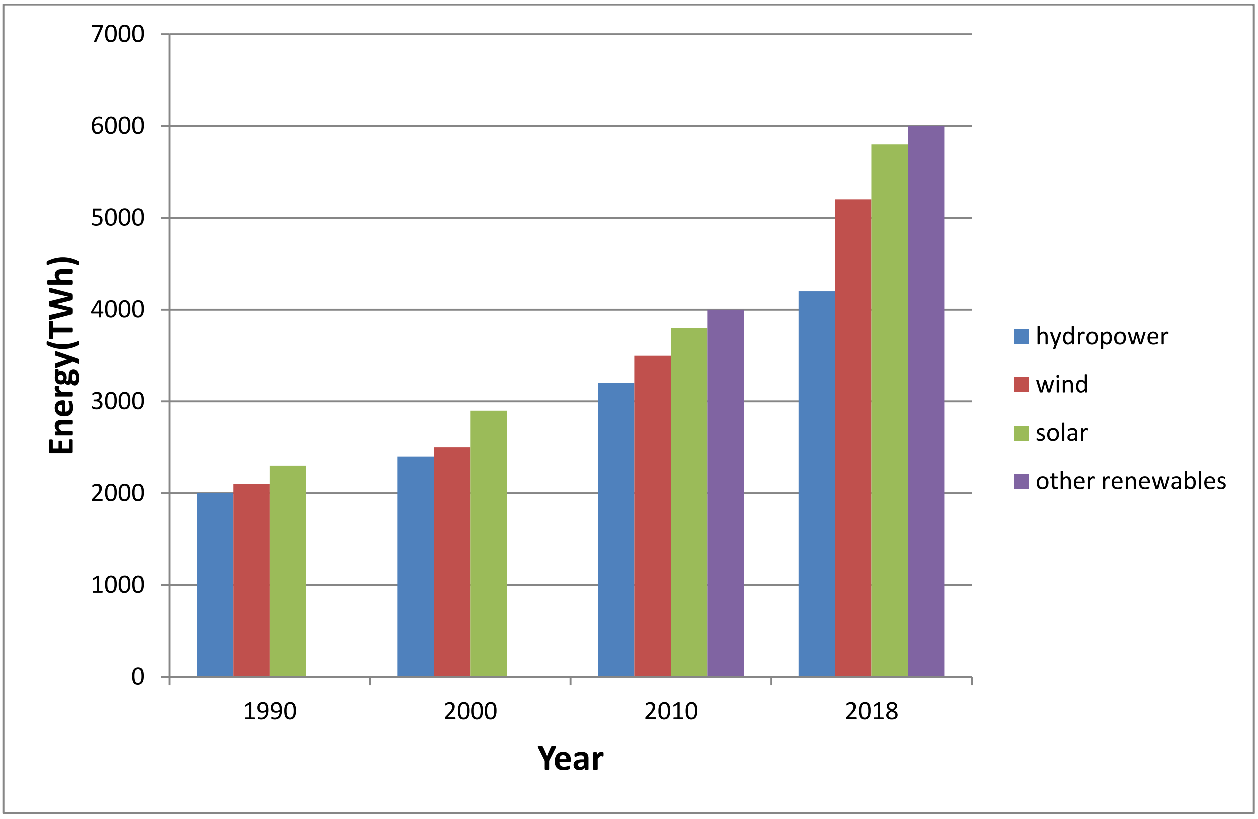

Figure 1-1: Renewable energy generation, world

Other renewables refer to geothermal, biomass waste, wave and tidal.

From the graphical representation in Figure 1-1 above, it shows that between 1990- 2000 there was no form of solar energy. Slowly the energy being generated from the sun increased within the years and at 2010 it had risen to 3800 TWh. It gradually increased from 3800- 5700 TWh between 2010- 2018. The energy from other renewable sources was not being utilized over the years (1990-2010) but at 2018 it is seen that in the mix, other renewables have the most percentage energy generation in creating a sustainable energy source. Thus it can be agreed that the use of biomass, geothermal wave and tidal sources are an important and effective way of generating energy.

Also over the years it is seen that hydropower are wind are equally major sources of energy development.

With Nigeria as a case study, this will be a suitable energy resource mix for sustainable energy at 2030. These estimations are made depending on the climatic actors and resources available in the country.

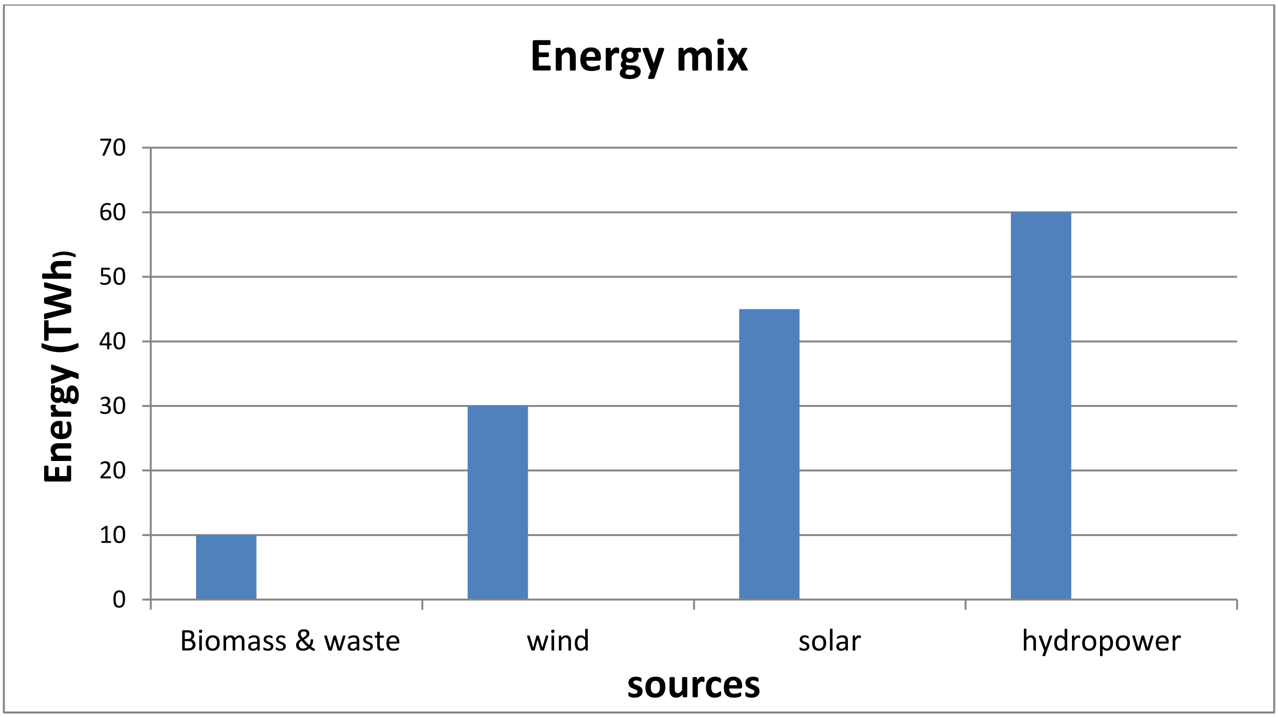

Figure 1-2: Energy mix for Sustainable development

2 ASSIGNMENT TWO

QUESTION ONE

Table 2-1: Average ambient temperature observed

DAY	DATE	T1(^{0}C)	T2(^{0}C)	T(^{0}C)
Monday	17/02/2020	35	26	30.5
Tuesday	18/02/2020	36	26	31
Wednesday	19/02/2020	36	26	31
Thursday	20/02/2020	36	26	31
Friday	21/02/2020	37	28	32.5

T1= Temperature during the day

T2= Temperature during the night

T= Average ambient temperature

The Stefan-Boltzmann equation then gives the energy flux emitted at the sun's surface.

$$S_S = \sigma * T^4 \qquad \textbf{(2-1)}$$

$$\sigma = 5.67 * 10^{-8} W m^{-2} K^{-4}$$

T=temperature in kelvin

The surface area of a sphere with a radius r is $\mathbf{4\pi r^2}$**.** If $\mathbf{r_s}$ is the radius of the Sun, the total energy it emits is $\boldsymbol{S * 4\pi r_s{}^2}$**.**[1]

As the radiation is emitted from this spherical surface, it is spread over larger and larger spherical surfaces, so the energy per square meter decreases.

When the energy emitted by the sun reaches the orbit of a planet, the large spherical surface over which the energy is spread has a radius, $\mathbf{r_P}$**,** equal to the distance from the sun to the planet. The energy flux at any place on this surface, $\mathbf{S_P}$, is less than what it was at the Sun's surface. But the total energy spread over this large surface is the same as the total energy that left the sun, so we can equate them[1]:

$$S_S 4\pi \boldsymbol{r_s}^{\mathbf{2}} = S_P 4\pi d_P{}^{\mathbf{2}}$$

$$S_P = S_S \left(\frac{r_S}{d_P}\right)^2 \qquad \textbf{(2-2)}$$

Where

S_S=energy flux emitted by the sun's surface

S_P=energy flux at any point on the planet earth surface

r_S= radius of the sun (700,000km)

d_P=radius of planet earth(150,000,000km)[1]

<u>Calculations</u>

Using the equations (2-1) and (2-2) above the thermal energy from the sun observed from Monday to Friday are calculated as follows

Monday: 30.5^{0}C =303.5^{0}K

$$S_S = (5.67 * 10^{-8} Wm^{-2}K^{-4}) * (303.5)^4 K^4$$

$$S_S = 481.1\ Wm^{-2}$$

$$S_P = 481.8 \left(\frac{700{,}000}{150{,}000{,}000}\right)^2$$

$$S_P = 10.493 Wm^{-2}$$

Tuesday, Wednesday and Thursday: 31^{0}C =304^{0}K

$$S_S = (5.67 * 10^{-8} Wm^{-2}K^{-4}) * (304)^4 K^4$$

$$S_S = 484.259\ Wm^{-2}$$

$$S_P = 484.259\left(\frac{700,000}{150,000,000}\right)^2$$

$$S_P = 10.546Wm^{-2}$$

Friday: 32.5^{0}C =305.5^{0}K

$$S_S = (5.67 * 10^{-8}Wm^{-2}K^{-4}) * (305.5)^4K^4$$

$$S_S = 493.887\ Wm^{-2}$$

$$S_P = 493.887\left(\frac{700,000}{150,000,000}\right)^2$$

$$S_P = 10.756Wm^{-2}$$

The thermal energy received from the sun between Monday- Friday is computed in Table 2-2 below**.**

Table 2-2: Thermal energy received from the sun

Days	Monday	Tuesday	Wednesday	Thursday	Friday
Thermal Energy(Wm^{-2})	10.493	10.546	10.546	10.546	10.756

QUESTION TWO

Figure 2-1: Anemometer[2]

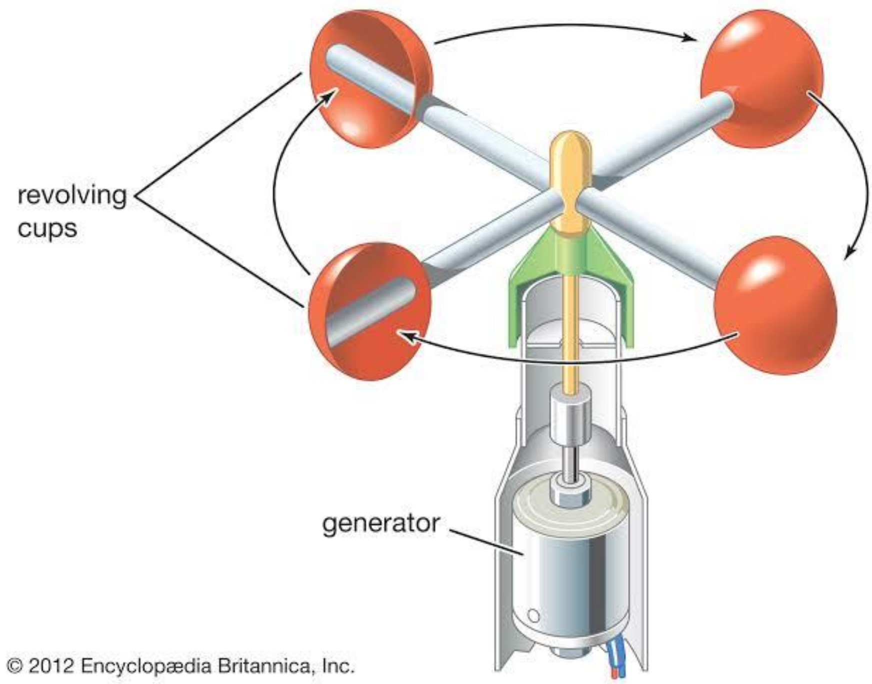

Figure 2-2: components of the Anemometer [2]

The cheapest and most widely used in ecological studies are cup or propeller anemometers, in which rotating cups or a propeller is driven by the wind. In the latter case, the device must either be held perpendicular to the direction of the wind or be mounted on a vane; for automated measurements such devices typically measure direction as well as speed. While mechanical anemometers are still in use in meteorological stations.[3]

The second form of anemometers used in ecological studies are hot-wire anemometers, in which an electrically heated wire element is cooled by the wind, and the wind speed calculated by the rate of heat loss. Unlike mechanical anemometers, these devices have a rapid response time and the lack of moving parts allows them to be installed close to the ground or within vegetation, so they have the potential for measuring small-scale eddies and microclimatic effects.

More complex ultrasonic anemometers measure wind speed in three directions based on the time of flight of sonic pulses between pairs of transducers. While expensive, such sonic anemometers are suitable for measuring turbulent air flow with a very high temporal resolution and are typically used in conjunction with infrared or laser-based gas analysers to measure ecosystem fluxes using the eddy covariance method.[3]

3 ASSIGNMENT THREE

Electricity, bedrock of every nation development and can be transported instantaneously and pollution free at consumer end makes it attractive as compared to other forms of energy. Although it is a desirable source of energy, being pollution free it also has its drawbacks: The construction of electric hydrogenating stations are highly dependent on the inflow of water into their reservoirs and this construction of hydroplants involves displacement of people from their natural habitat and destruction of species of plants and animals. Therefore, the construction of power generating stations has substantial impact on its immediate environment; these consequences may be positive impacts that are useful to the environment and also negative effects that are hazardous to the environment. The effective management of these impacts of electric power generation in Nigeria, so as to ensure a conducive, balance and sustainable environment is highly desirable. [4]

However the intake level or quantity of water into the hydro power generation power stations differs. It varies with respect to the position of the hydro power stations and prevailing seasons experience at a particular point in time.

Nigeria is blessed with large rivers and natural falls. The three main sources of water flow for hydro power generation are the Kanji, Jebba and shiroro. The monthly hydrological water balance for energy generation on the kanji reservoir operation for 2015 was observed and estimated to be **1,621,534 MWH**; and the energy generated from the shiroro reservoir was estimated to be **1,440,601 MWH.**[4]

Nigeria has oil reserves of about 35 billion barrels ($3.5*10^9 m^3$) and gas reserves of 5 trillion cubic meters. Crude oil which is a major source of energy production is used as to produce transportation fuels, such as gasoline, diesel and jet fuel.it is also used for heating and electricity generation. At 2015 Nigeria produced 1.9 million barrels/day of crude oil and the primary energy generated was estimated to be 1476 TWH which is **1,476,000,000MWH.** [5]

In comparison it can be seen that in 2015, the amount of energy produced in Nigeria from crude oil was **exponentially higher** than that produced from dams. And this is because the amount of reserves for the crude oil is significantly larger than that of the hydropower; **36.2 billion barrels for the former and 14,250MW for the latter.**[6]

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[6] S. O. Oyedepo, "Energy and sustainable development in Nigeria : the way forward," pp. 1–17, 2012.